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011604

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Dated 23 December 2003



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OLIFF & BERRIDGE, PLC

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ALEXANDRIA, VA 22320

(703) 836-6400

APPLICANT: Christopher Peter Ralph HILL et al.

APPLICATION NO.: New U.S. Application

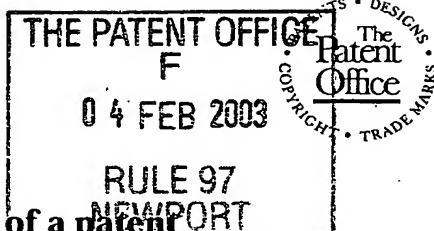
FILED: January 16, 2004

FOR: PRODUCTION OF DISC COMPONENTS

ATTORNEY DOCKET NO.: 118285

Patents Form 1/77

Patents Act 1977
(Rule 16)



05FEB03 E782398-1 D01097
P01/7700 0.00-0302553.3

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

- 4 FEB 2003

1. Your reference PAT/GPW/3083

2. Patent application number
(The Patent Office will fill in this part)

0302553.3

5 FEB 2003

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

ROLLS-ROYCE plc
65 BUCKINGHAM GATE
LONDON
SW1E 6AT
GREAT BRITAIN

Patents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

GREAT BRITAIN

3970002

4. Title of the invention PRODUCTION OF DISC COMPONENTS

5. Name of your agent (*if you have one*)

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

MR V J BIRD
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ROLLS-ROYCE plc
PO BOX 3
FILTON
BRISTOL
BS34 7QE

Patents ADP number (*if you know it*)

65789006

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (*if you know it*) the or each application number

Country

Priority application number
(*if you know it*)

Date of filing
(*day / month / year*)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
(*day / month / year*)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (*Answer 'Yes' if:*

YES

- a) any applicant named in part 3 is not an inventor, or
 - b) there is an inventor who is not named as an applicant, or
 - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77

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Continuation sheets of this form 0

Description 6

Claim(s) 2

Abstract 1

Drawing(s) 2 + 2 825

10. If you are also filing any of the following, state how many against each item.

Priority documents 0

Translations of priority documents 0

Statement of inventorship and right to grant of a patent (Patents Form 7/77) YES

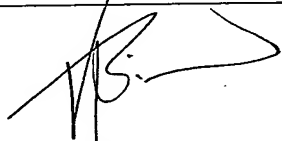
Request for preliminary examination and search (Patents Form 9/77) YES

Request for substantive examination (Patents Form 10/77) NO

Any other documents (please specify) NO

11.

I/We request the grant of a patent on the basis of this application.



Signature

Date

V J BIRD

3 FEBRUARY 2003

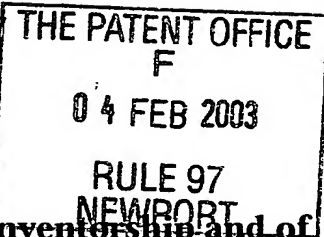
12. Name and daytime telephone number of person to contact in the United Kingdom PAUL WALKER 0117 979 7416
paul.walker@rolls-royce.com

s.iudum

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Statement of inventorship and of right to grant of a patent

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

- 4 FEB 2003

1. Your reference PAT/GPW/3083

2. Patent application number
(if you know it)

0302553.3

3. Full name of the or of each applicant ROLLS-ROYCE plc

4. Title of the invention

PRODUCTION OF DISC COMPONENTS

5. State how the applicant(s) derived the right from the inventor(s) to be granted a patent

BY VIRTUE OF THE INVENTORS' TERMS AND CONDITIONS OF EMPLOYMENT

6. How many, if any, additional Patents Forms 7/77 are attached to this form?
(see note (c))

NO

7.

I/We believe that the person(s) named over the page (and on any extra copies of this form) is/are the inventor(s) of the invention which the above patent application relates to.

Signature

Date

V J BIRD

3 FEBRUARY 2003

8. Name and daytime telephone number of person to contact in the United Kingdom

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paul.walker@rolls-royce.com

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Patents Form 7/77

Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

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Patents ADP number (if you know it): 81 38711 001

BENJAMIN MYCOCK
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Patents ADP number (if you know it): 8558777 001

Reminder

Have you signed the form?

PRODUCTION OF DISC COMPONENTS

This invention relates to a method of producing, from a workpiece, a finished disc component for a gas turbine engine. The invention is particularly, although not exclusively, concerned with the production of turbine disc components, but may be applied also to other components such as compressor discs and coverplates.

Discs for gas turbine engines are highly critical parts that are severely loaded during operation. It is known to produce such discs from forgings, castings, or powdered metal forms, which are initially machined to create a starting workpiece of rectilinear shape suitable for ultrasonic inspection to detect flaws. After this inspection, the starting workpiece is machined to the final shape.

Residual stresses exist in the starting workpiece as a result of the manufacturing process. Consequently, as material is removed during the machining process, these stresses cause distortion which must be eliminated in subsequent machining operations so that the finished disc is free of distortion.

To achieve this in a current technique, the starting workpiece is clamped at its periphery and successive machining operations are conducted alternately on one face of the disc and on the other, and so on until all machining operations are completed. As presently conducted, the process requires the workpiece to be moved from one fixture to another between machining operations in order to expose the face to be machined at each step. This creates additional distortions as the periphery of the disc is successively constrained by and released from different fixtures. In addition, there are changes in the datum faces which locate the workpiece in the machining centre, and the workpiece has to be set up again in the machine tool with each change of fixture. These factors result in a loss of accuracy.

The current methods require up to sixteen turning operations, and the need to move the workpiece from one fixture to another between each operation means that the entire machining process is very lengthy, prone to errors, provides many opportunities for the

workpiece to be damaged. By way of example, the machining of a turbine disc by current methods can require nineteen hours for rough machining followed by sixteen hours of finish machining.

According to the present invention there is provided a method of producing, from a workpiece, a finished disc component for a gas turbine engine, the workpiece having a hub portion and a disc portion extending radially outwardly from the hub portion, the method including:

forming a support surface on the hub portion;

supporting the workpiece in a machine tool by means of the support surface in a manner which provides tool access to both axial faces of the disc portion; and

performing a sequence of machining operations alternately on opposite sides of the disc portion while maintaining the support of the workpiece by means of the support surface.

The support surface is preferably cylindrical and centred on the longitudinal axis of the workpiece. The support surface may be either an internal or an external support surface for locating engagement with a suitable fixture.

The fixture may be mounted for rotation in a machine tool such as a lathe. The fixture may be secured to the workpiece substantially at one axial end of the hub, and the opposite axial end of the hub may be supported by a tailstock of the machine tool. The support surface may be a cylindrical bore extending completely through the hub portion, in which case the fixture and the tailstock may engage opposite axial ends of the bore. Alternatively, a second support surface may be formed on the hub portion so that the fixture and the tail stock engage different support surfaces.

The outer periphery of the disc portion is preferably unconstrained during all or most of the sequence of machining operations. In other words, the workpiece is supported solely at the hub portion, either by a fixture alone or by the fixture and a tailstock.

When material is removed from the workpiece, the resulting distortion can take time to develop fully. Consequently, during the sequence of machining operations, strain relieving periods of predetermined duration may be left between successive operations. This is to allow distortion to take place following a preceding machining operation on one face of the disc portion before a succeeding operation is carried out on the opposite face of the disc portion.

In order to eliminate distortion in the finished disc component, it is preferable for all rough and/or semi-finish machining operations on the disc portion to be completed on both faces of the disc portion before any finishing operations are conducted on the disc portion. In particular, machining operations in which relatively large quantities of material are removed are preferably carried out early in the sequence of operations. Also, it is preferable for regions of the disc portion having high residual stress (by comparison with other regions of the disc portion) to be removed before regions having lower residual stress. These measures ensure that maximum distortion of the disc occurs at early stages in the sequence of machining operations, while there is still plenty of material on the workpiece which is subsequently removed to compensate for the distortions which occur.

The present invention also provides a disc component formed by a method as defined above, and a disc assembly incorporating the component.

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 represents a workpiece supported by a fixture; and

Figure 2 represents a similar workpiece supported by an alternative fixture.

Figure 1 shows the outline of a turbine disc 2 disposed within the outline of a starting workpiece 4. The starting workpiece 4 is machined from a raw forging and comprises a hub portion 6 and a disc portion 8. The hub portion 6 has a central cylindrical bore 10 which is centred on the longitudinal axis 12 of the workpiece.

It will be appreciated that the starting workpiece 4 is of relatively simple structure. The central bore 10 is of constant diameter throughout and the outer surface of the hub portion 6 comprises three cylindrical surfaces 14, 16 and 18. The hub portion 6 has radially extending axial end faces 20 and 22, and a third radially extending surface 24 connects the cylindrical surfaces 14 and 16. The disc portion 8 comprises radially extending axial end faces 26 and 28, and a cylindrical peripheral surface 30.

The relatively simple shape of the starting workpiece 4 makes it suitable for inspection, for example ultrasonic inspection, to establish whether or not any flaws exist in the raw forging which will affect the integrity of the finished disc 2. If the starting workpiece 4 passes these tests it is prepared for further machining.

For this machining, the workpiece 4 needs to be supported reliably. During the forging process, stresses are created in the raw forging, and most of these residual stresses remain in the starting workpiece 4. As material is removed to form the finished disc 2, these residual stresses will be released, resulting in distortion of the workpiece as machining proceeds. For reliable support of the workpiece 4 during the machining operation, it is desirable for the workpiece 4 to be supported at a region of high stiffness and low residual distortion in order to minimise movement of the support surface as machining proceeds.

In the starting workpiece 4 of Figure 1, this area of high stiffness and low distortion is at the radially inner region of the hub, generally in radial alignment with the disc portion 8. Thus, the region of the inner bore 10 towards the right-hand end of the workpiece 4, as seen in Figure 1, is used as a radial support surface 32, while the radially inner region

of the end surface 22 serves as an axial support surface 34. A fixture 36 engages the support surfaces 32 and 34, and is rigidly secured to the starting workpiece 4. It will be appreciated that, with the starting workpiece 4 supported on the fixture 36, most of the external surface of the workpiece 4 is accessible by cutting and finishing tools. In particular, both faces 26 and 28 of the disc portion 8 are accessible without needing to remove the workpiece 4 from the fixture 36.

The disc portion of the finished disc 2 is created by a carefully controlled sequence of machining operations on the disc portion 8. Each metal removal step releases residual stress in the workpiece 4, resulting in distortion. Consequently, machining operations are performed alternately on opposite sides of the faces 26 and 28 so that distortion arising from any individual machining operation is compensated for by subsequent machining operations.

It is desirable for early machining operations in the sequence to remove material at regions of higher residual stress. This will cause maximum distortion of the disc portion 8 but, at that stage, there is plenty of material left to enable this distortion to be compensated for by the removal of further material in subsequent machining operations.

It is also desirable for the sequence of machining operations to be programmed so that the stiffness of the workpiece at any stage is sufficient to withstand the machining forces applied to it.

In practice, all rough machining and semifinish machine should be completed before finish machining operations are performed.

Since the release of residual stress on removal of material does not occur immediately, it is desirable for some machining operations to be deferred for a predetermined time following the immediately preceding machining operation, so that the full distortion arising from the immediately preceding operation has taken place before the next successive operation begins.

During the machining operations on the faces 26 and 28 of the disc portion 8, the workpiece 4 remains secured to the fixture 36. Furthermore, many of the machining operations on the hub portion 6 can be accomplished while the workpiece 4 is on the fixture 36. This saves the time which might otherwise be taken in removing the workpiece 4 from one fixture and securing it to a second fixture between machining operations. Also, all of the machining operations, at least on the disc portion 8, can be accomplished by reference to only a single datum, whereas a change of fixture would require the setting of a new datum.

The use of the fixture 36 supporting the hub of the workpiece 4 enables the machining process to be extensively automated, particularly if the machining operations are carried out on a CNC lathe with tool changing capability. The ready access to both faces 26 and 28 of the disc portion 8 enables rapid changeover from a machining operation on one face to a machining operation on the opposite face, where no delay is required to enable distortion to take effect.

The use of a single fixture 36 and the resulting increase in cycle time between machining operations reduces manual handling of the workpiece 4, work in progress, floor space required and the number of fixtures 36 needed for each disc design. Preliminary indications are that the time taken to produce a finished disc 2 from a forging can be reduced from approximately 35 hours using current techniques to less than 6½ hours using a procedure as described above.

Figure 2 shows an alternative supporting arrangement for the starting workpiece 4. In Figure 2, the workpiece 4 and the finished disc 2 are substantially identical to those shown in Figure 1, and their features are referred to by the same reference numerals.

In Figure 2, the workpiece 4 is supported at the cylindrical surface 14 by a fixture 38, with additional support being provided by an automatic tailstock 40. As with the arrangement of Figure 1, the fixture 38 is rigidly secured to the workpiece 4 and is mounted for rotation in a lathe.

CLAIMS

- 1 A method of producing, from a workpiece, a finished disc component for a gas turbine engine, the workpiece having a hub portion and a disc portion extending radially outwardly from the hub portion, the method including:

forming a support surface on the hub portion;

supporting the workpiece in a machine tool by means of the support surface in a manner which provides tool access to both axial faces of the disc portion; and

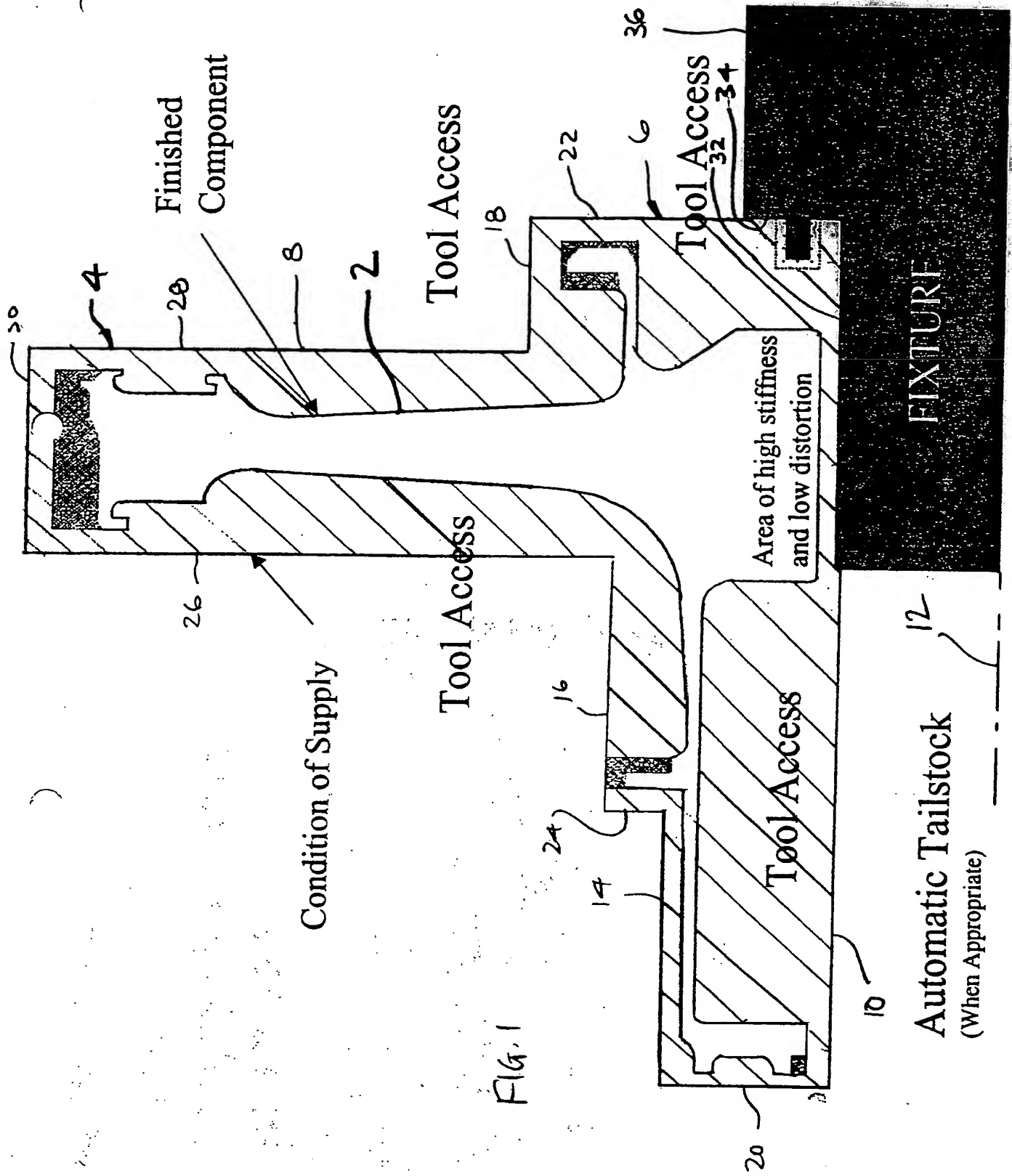
performing a sequence of machining operations alternately on opposite sides of the disc portion while maintaining the support of the workpiece by means of the support surface.
- 2 A method as claimed in claim 1, wherein the finished disc component is produced from a forged workpiece.
- 3 A method as claimed in claim 1 or claim 2, in which the support surface is cylindrical and aligned with a longitudinal axis of the workpiece.
- 4 A method as claimed in any preceding claim , in which the support surface is an internal surface of the hub portion.
- 5 A method as claimed in claim 1, claim 2 or claim 3, in which the support surface is an external surface of the hub portion.
- 6 A method as claimed in any one of the preceding claims, in which the workpiece is supported by a fixture which engages the support surface and is non-rotatably secured to the workpiece.

- 7 A method as claimed in claim 6, in which, in addition to the fixture, a tailstock engages the workpiece at a position spaced from the fixture.
- 8 A method as claimed in any one of the preceding claims, in which the outer periphery of the disc portion is unconstrained during at least some of the machining operations.
- 9 A method as claimed in any one of the preceding claims, in which at least one of the machining operations is delayed after completion of the immediately preceding machining operation, until distortion resulting from the immediately preceding machining operation has taken effect.
- 10 A method as claimed in any one of the preceding claims, in which finish machining operations on the disc portion take place after all rough and semifinish machining operations on both faces of the disc portion have been completed.
- 11 A method as claimed in any one of the preceding claims, in which regions of the workpiece in which there is high residual stress are removed in machining operations occurring early in the sequence of machining operations.
- 12 A method of producing, from a workpiece, a finished disc component for a gas turbine engine, the method being in accordance with claim 1 and substantially as described herein.
- 13 A disc component produced by a method in accordance with any one of the preceding claims.
- 14 A disc assembly including a disc component in accordance with claim 13.

ABSTRACT**PRODUCTION OF DISC COMPONENTS**

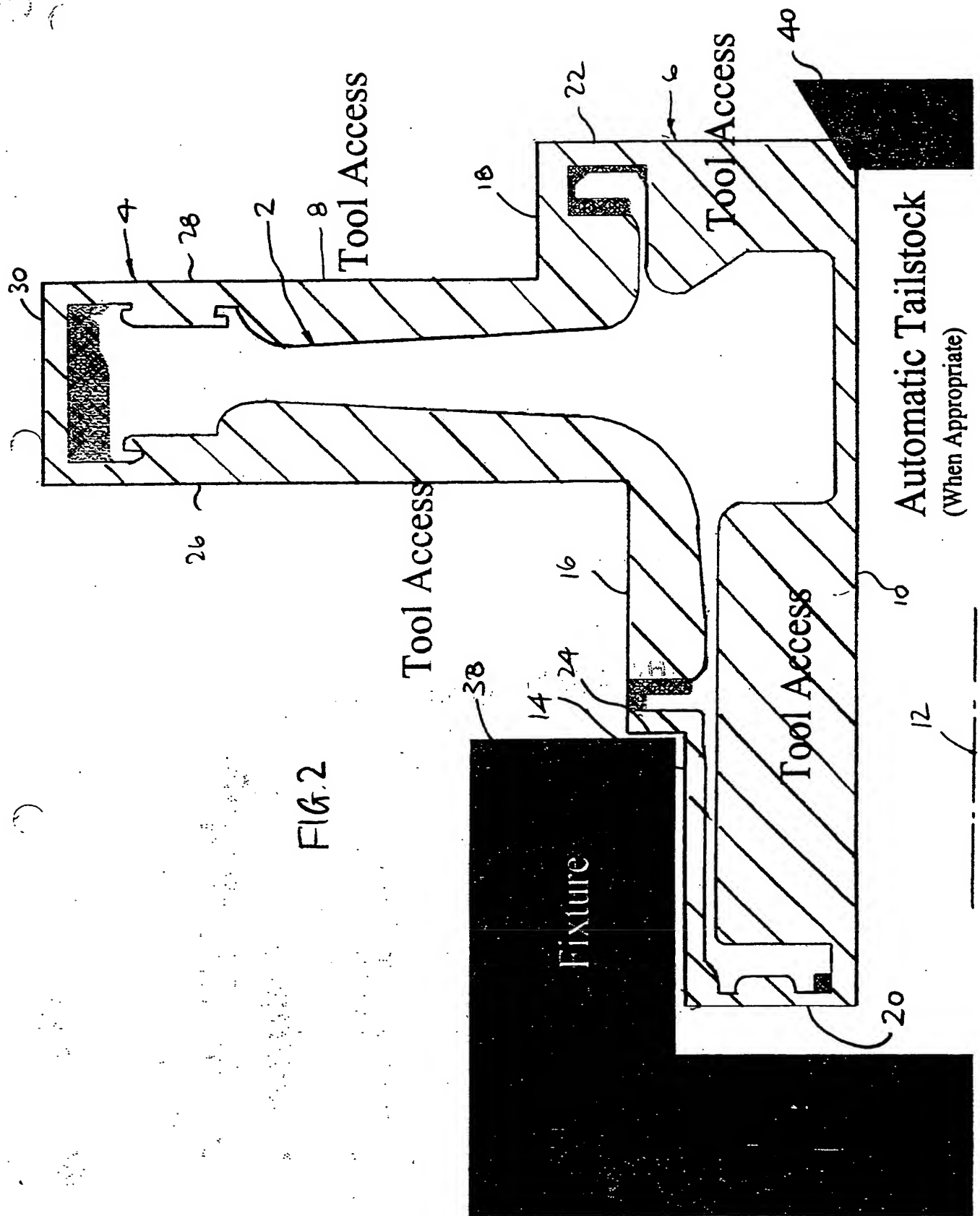
A disc component 2 for a gas turbine engine is produced from a workpiece 4 by a sequence of machining operations. During the machining operations, the workpiece 4 is supported by a fixture 36 engaging support surfaces 32, 34. The workpiece 4 remains secured to the fixture 36 throughout the sequence of machining operations so that these operations can be conducted on both faces 26, 28 of a disc portion 8 of the workpiece 4 without removing the workpiece 4 from the fixture 36. The machining operations are conducted alternately on the opposite faces 26, 28 in order to allow residual stresses in the workpiece 4 to dissipate in a controlled manner.

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FIG. 2



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